Follow-up after surgical closure of congenital ventricular septal defect

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Received 3 February 2003; received in revised form 16 May 2003; accepted 23 June 2003

Abstract

Objectives: The purpose of this retrospective study was to assess long-term outcome of children after surgical closure of a ventricular septal defect (VSD). Material and methods: Between January 1992 and December 2001 a consecutive series of 188 patients (100 females) were operated for closure of a VSD. Temporary tricuspid valve detachment (TVD) was applied in 46 patients (24\%) to enhance exposure of the defect using transatrial approach. Pre-operative baseline characteristics showed that the detached group was younger (0.79 ± 1.8 vs
2.1 ± 3.5 years, \(p = 0.002\)) and had a lower weight (6.5 ± 6.4 vs 10.0 ± 11.0 kg, \(p = 0.009\)). Results: There was no difference in cross-clamp time (temporary TVD 36.2 ± 11.3 vs non-temporary TVD 33.6 ± 13.1 min, \(p = 0.228\)). Postoperative echocardiography showed that 67 patients (36\%) had trivial/minimal regurgitation, 10 patients (22\%) from the temporary TVD group vs 57 patients (40\%) from the non-detached group (\(p = 0.02\)). There was no tricuspid stenosis. Hospital mortality comprised two patients (1\%). One patient died due to a pulmonary hypertensive crisis and one in relation to an acute patch dehiscence for which an emergency reoperation was necessary. At first postoperative echocardiography no shunting was detected in 113 patients, trivial shunting in 73 and significant shunting in none. Multivariate logistic regression analysis revealed that weight at operation was a predictive factor for the occurrence of residual shunting (OR 0.95, C.I. 0.91–0.99). One patient with conduction disturbances needed a permanent DDD-pacemaker. Three patients were lost to follow-up. Mean follow-up time was 2.6 years (range 0.1–9.4). During follow-up no reoperations were necessary for closing a residual VSD. One patient died 7 months postoperative due to a bronchopneumonia. During follow-up in 37 (51\%) of the 73 patients the trivial shunting disappeared spontaneously at a median time of 3.9 years. According to actuarial analysis all trivial shunting had disappeared at 8.4 years. Conclusion: Trivial residual shunting disappeared spontaneously at a median follow-up time of 3.9 years. During follow-up no patient needed to be reoperated for residual VSD. TVD proved to be a safe method to enhance the exposure of a VSD.

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Keywords: Ventricular septal defect; Congenital; Follow-up studies; Surgery

1. Introduction

The most frequent congenital cardiac anomaly is a ventricular septal defect (VSD) [1,2]. Many VSDs are small, asymptomatic and are assumed to close spontaneously [3]. In the VSDs that need closure, surgical treatment is aimed at prevention of pulmonary hypertension, endocarditis or in some instances of progressive aortic valve regurgitation [4].

After surgical closure of a VSD trivial residual shunting is nowadays easily detected with modern sensitive echocardiographic techniques. However, the natural history of these small shunts is yet unknown especially with regard to temporary tricuspid valve detachment (TVD) [5]. In closing a VSD temporary TVD may provide better exposure of the defect in the usual transatrial approach [6–8]. Details of follow-up after surgical VSD-closure using TVD are scarce with regard to tricuspid valve function and residual shunting. In this regard we report our analysis of patients who underwent surgical closure of a VSD under 17 years of age, between January 1992 and December 2001 with special emphasis on temporary TVD and spontaneous closure of residual trivial shunting.

2. Material and methods

Between January 1992 and December 2001, 188 consecutive patients younger than 17 years of age were...
operated upon for closure of a congenital VSD. The study group consisted of 100 female (53%) and 88 male (47%) patients. Although the mean age at operation was 1.8 years (range 2.5 weeks–14.8 years) the median age was only 0.4 years. None of them had previously been operated upon. The Wolff Parkinson White syndrome in two patients was medically controlled. One hundred and thirty-nine patients (75%) had one or more concomitant cardiac defects that were surgically corrected during the same operation. Patients’ characteristics are described in Table 1. Exercise intolerance was regarded present in the younger children when ability to exercise was less compared to siblings. All patients were operated upon with cardiopulmonary bypass (mean duration of 64±25 min, range 31–311 min). Mean cross-clamp time was 34^\text{13 min}

Table 1

<table>
<thead>
<tr>
<th>n</th>
<th>Mean</th>
<th>Range</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.8 years</td>
<td>2.5 weeks–14.8 years</td>
</tr>
<tr>
<td>Weight</td>
<td>9.1 kg</td>
<td>2.2–49 kg</td>
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<tr>
<td>Percentile</td>
<td>29</td>
<td>1–99</td>
</tr>
<tr>
<td>Height</td>
<td>0.72 m</td>
<td>0.35–1.64 m</td>
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<tr>
<td>Percentile</td>
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<td>1–99</td>
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<tr>
<td>Diuretics</td>
<td>140 (74%)</td>
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<tr>
<td>Decreased exercise</td>
<td>143 (76%)</td>
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<tr>
<td>Concomitant syndromal anomalies</td>
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<td></td>
</tr>
<tr>
<td>Down’s syndrome</td>
<td>26 (14%)</td>
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<td>Jacobsen syndrome</td>
<td>10 (5%)</td>
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<td>Melas syndrome</td>
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<tr>
<td>Sotos syndrome</td>
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<td>VACTERL association</td>
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<tr>
<td>Left ventricular hypertrophy</td>
<td>25 (13%)</td>
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</tr>
<tr>
<td>Right ventricular hypertrophy</td>
<td>39 (21%)</td>
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</tr>
<tr>
<td>Biventricular hypertrophy</td>
<td>71 (38%)</td>
<td></td>
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<tr>
<td>A–V-conductance disorders</td>
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<td>Wolff Parkinson White syndrome</td>
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<td></td>
</tr>
<tr>
<td>Tricuspid valve insufficiency</td>
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<tr>
<td>Normal</td>
<td>129 (69%)</td>
<td></td>
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<tr>
<td>Minimal/trivial</td>
<td>56 (30%)</td>
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<tr>
<td>Severe</td>
<td>3 (1%)</td>
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<tr>
<td>Catheterization</td>
<td>35 (19%)</td>
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<tr>
<td>Associated cardiac defects</td>
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<td></td>
</tr>
<tr>
<td>ASD</td>
<td>103 (55%)</td>
<td></td>
</tr>
<tr>
<td>PAD</td>
<td>5 (3%)</td>
<td></td>
</tr>
<tr>
<td>ASD and PAD</td>
<td>29 (15%)</td>
<td></td>
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<tr>
<td>Aortic coarctation with ASD and PAD</td>
<td>1 (0.5%)</td>
<td></td>
</tr>
<tr>
<td>Aortic coarctation with PAD</td>
<td>1 (0.5%)</td>
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</tr>
</tbody>
</table>

ASD, atrial septal defect; PAD, patent arterial duct.

the tricuspid valve was detached in 46 cases (24%): the anterior leaflet in 22 patients (48%), the septal in 10 (22%) and both leaflets in 14 (30%). TVD was selectively applied in cases with multiple chordal attachment to the rim of the VSD. The technique was exactly as described in our previous paper [6]. Essentially, the incision for detachment is made in the leaflet, about 1 mm inside the annulus. After closure of the VSD, a separate continuous suture line 7-0 or 6-0 polypropylene was used to reattach the leaflets. In addition to a right atriotomy, two patients (both non-TVD) required a second approach: one needed an additional left ventriculotomy for an apically situated central muscular VSD, the other an additional pulmonotomy to enhance the exposure of an outlet VSD. TVD was used more frequently in the first half of the series (32 out of 94, 34%) compared to the second half (14 out of 94, 15%).

The type of VSD was finally determined at the time of surgery: 173 (92%) were perimembranous, four inlet (2%), four outlet (2%) and seven central muscular (4%). One VSD complicated by endocarditis was closed with autologous pericardium, all the others were closed with a Gore-Tex patch. Postoperative echocardiography was performed with 2D and color-Doppler and used to assess tricuspid valve function as well as possible residual shunting. Tricuspid valve regurgitation was graded as none, trivial or severe, based on the area and the length of the color jet. Residual shunting was defined as no residual shunting as no detectable color jet; trivial residual shunting as a minimal color jet and significant residual shunting as detectable VSD with an important color jet.

Follow-up concerning the presence of a residual shunting and evaluation of the tricuspid valve was complete in 177 patients (95%). Endpoints with respect to residual shunts were reoperation for residual VSD or spontaneous closure of the shunt as evaluated by echocardiography at the outpatient clinic. Three patients were lost to follow-up because they left the country shortly after operation. Hospital mortality was defined as death within 30 days postoperative. The mean follow-up time was 2.6 years (range 0.1–9.4 years).

2.1. Statistical analysis

The analysis of categorical variables was performed with \( \chi^2 \)-test. Continuous variables, described as the mean ± standard deviation were analyzed using the independent Student’s \( t \)-test. Logistic regression analysis was used to analyze predictive values for residual shunt at discharge. A significant difference was found when probability values were smaller than 0.05.

3. Results

At operation the group with TVD was younger (mean age 0.8 ± 1.8 (median 0.38) vs 2.1 ± 3.5 years (median 0.41),
had a lower weight (6.5 ± 6.4 vs 10.0 ± 11.0 kg, \( p = 0.002 \)) and were shorter in length (0.63 ± 0.17 vs 0.75 ± 0.31 m, \( p = 0.004 \)) compared to the non-TVD group. There were no significant differences between the two groups concerning pre-operative use of diuretics (\( p = 0.24 \)), failure to thrive (\( p = 0.29 \)) or exercise intolerance (\( p = 0.14 \)). Cardiopulmonary bypass time was not significantly different (TVD group 62 ± 14 min vs non-TVD group 64 ± 28 min, \( p = 0.61 \)). The groups also did not differ in cross-clamp time (TVD 36 ± 11 min vs non-TVD 33 ± 13 min, \( p = 0.23 \)). Two patients died during their hospital stay. One patient (TVD group) with pulmonary hypertension died during the operation because of a pulmonary hypertensive crisis. One patient (non-TVD group) died on the first postoperative day in relation to acute patch dehiscence, despite an emergency reoperation. One patient needed a resternotomy because of persistent blood loss. Two other patients needed prolonged postoperative ventilation support (both 10 days) and in two more the sternum was closed secondarily because of initial hemodynamic instability. Because of persistent complete atrioventricular block in one patient a permanent VVI-pacemaker was implanted. There were 186 early survivors; one patient died 7 months postoperative due to a bronchopneumonia.

The types of VSD in the TVD and non-TVD groups did not differ (perimembranous \( n = 43, 93\% \) vs \( n = 130, 92\% \); inlet \( n = 1, 2\% \) vs \( n = 3, 2\% \); outlet \( n = 0, 0\% \) vs \( n = 4, 3\% \) and central muscular \( n = 2, 4\% \) vs \( n = 5, 4\% \)).

The postoperative echocardiographic assessment of tricuspid valve function was: 121 patients (64\%) had no tricuspid valve regurgitation, 67 patients (36\%) had trivial regurgitation, and none had severe tricuspid valve regurgitation. From the 67 patients with trivial/minimal regurgitation 10 (22\%) were from the TVD group and 57 (40\%) from the non-detached group (\( p = 0.02 \)).

Postoperative echocardiography showed residual shunting in 73 patients, all trivial. The median time of echocardiographically proven spontaneous closure was 3.9 years. The incidence of a residual shunt did not differ (TVD vs non-TVD 17 vs 56, \( p = 0.48 \)). During follow-up 37 (51\%) of the residual shunts closed spontaneously. As illustrated in Fig. 1 all residual shunts are expected to close within 10 years. In a univariate logistic regression both lower age and lower weight at operation were predictive of residual shunting at hospital discharge (see Table 2). In the multivariate logistic regression only lower weight at operation was predictive (odds ratio 0.95, confidence limits 0.91–0.99).

At mid-term follow-up there was no significant (\( p = 1.0 \)) difference in incidence of trivial tricuspid valve regurgitation between the non-TVD group (\( n = 15, 11\% \)) and TVD group (\( n = 15, 11\% \)). The presence of left ventricular hypertrophy on electrocardiogram was reduced from 25 patients to two (92\% reduction); right ventricular hypertrophy was reduced from 38 to 4 (89\% reduction) and a complete reduction in hypertrophy was seen in patients with biventricular hypertrophy (71 patients). Use of diuretics showed a 92\% reduction (from 127 patients to 10) and failure to thrive and exercise intolerance were reduced with 94\% (from 134 to 8). The mean weight percentiles increased for the whole group from 16 ± 23 to 40 ± 30 as did the mean height percentile: 29 ± 28 to 40 ± 30.

### 4. Discussion

Detachment of the tricuspid valve may improve visualization of the margins of a VSD and can thereby

\[ \text{Fig. 1. Prediction of residual shunting after surgical closure of a ventricular septal defect.} \]
the more likely a residual shunt existed at discharge. Obviously, in closing a VSD in a smaller patient, the balance between prosthesis compliance and tissue friability is different.

Tatebe et al. [13] in their study concluded that detachment of the tricuspid valve should be avoided in patients with Down’s syndrome and small infants because of a higher incidence of tricuspid valve regurgitation. In our series 26 patients (nine TVD, 17 non-TVD) had Down’s syndrome. There was no significant \( p = 0.613 \) difference in regurgitation between the TVD group (four patients (44%) with trivial TI) and the non-TVD group (eight patients (47%) with trivial TI). This suggests that TVD in patients with Down’s syndrome can be performed safely.

In contrast to the finding of Tatebe et al. [13] in the group of small children with a pre-operative weight under the 10th percentile (122, 33 detached, 89 non-detached) postoperative tricuspid valve regurgitation was significantly \( p = 0.009 \) higher in the non-detached group (38, 43%) vs the detached group (6, 18%).

Patients with VSD demonstrate satisfactory bodyweight gain after VSD-closure [14]. This study also showed an increase in weight and length percentile postoperatively. Total energy expenditure is 40% higher in children with a VSD compared to healthy controls [15]. This study confirms that closure of a VSD results in a catch-up growth after closure.

This study illustrates that closure of a VSD can be performed with a low complication rate. Tricuspid valve detachment is a safe method to enhance the exposure of a VSD. TVD results in less early postoperative tricuspid valve regurgitation and does not result in tricuspid valve dysfunction during follow-up. TVD results in comparable residual shunting as non-TVD. The incidence of trivial residual shunting is higher in small children irrespective of tricuspid valve detachment. Trivial residual shunting is expected to disappear spontaneously.

### References


